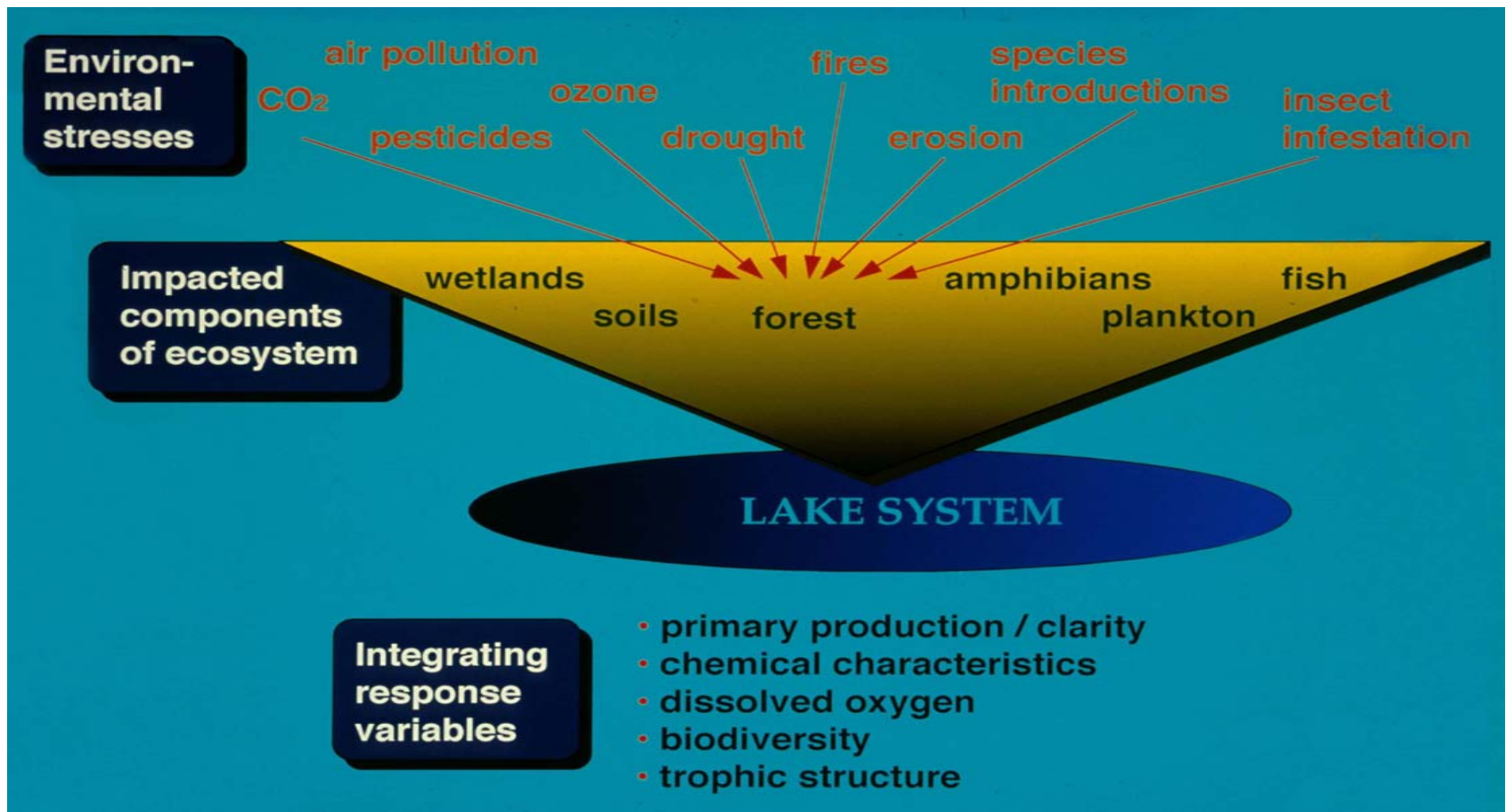


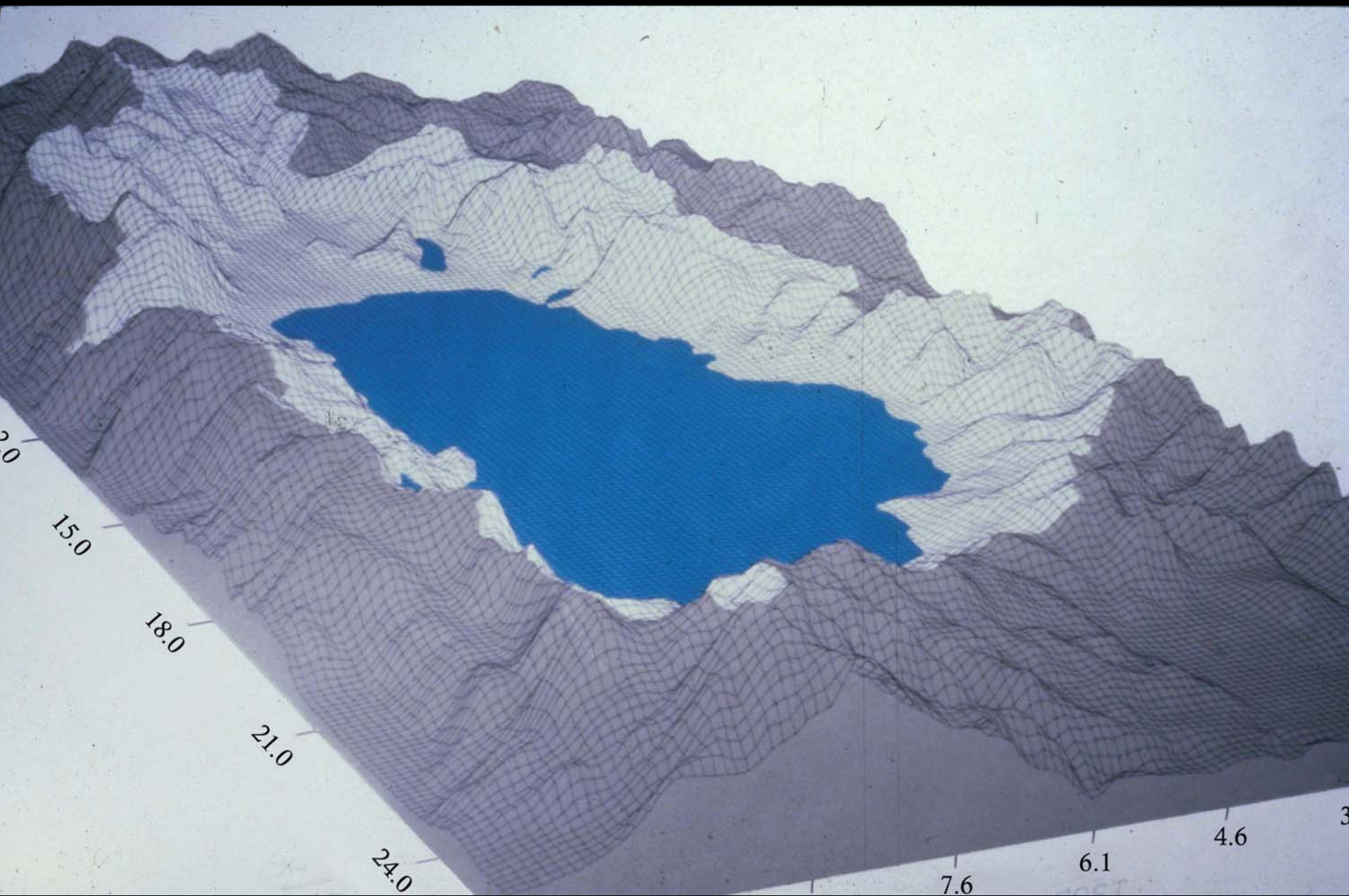


Lessons in Critical Ecosystem Protection The Role of Science in Management Decisions at Lake Tahoe CA/NV

Charles R. Goldman
Professor of Limnology
University of California,
Davis, CA 95616

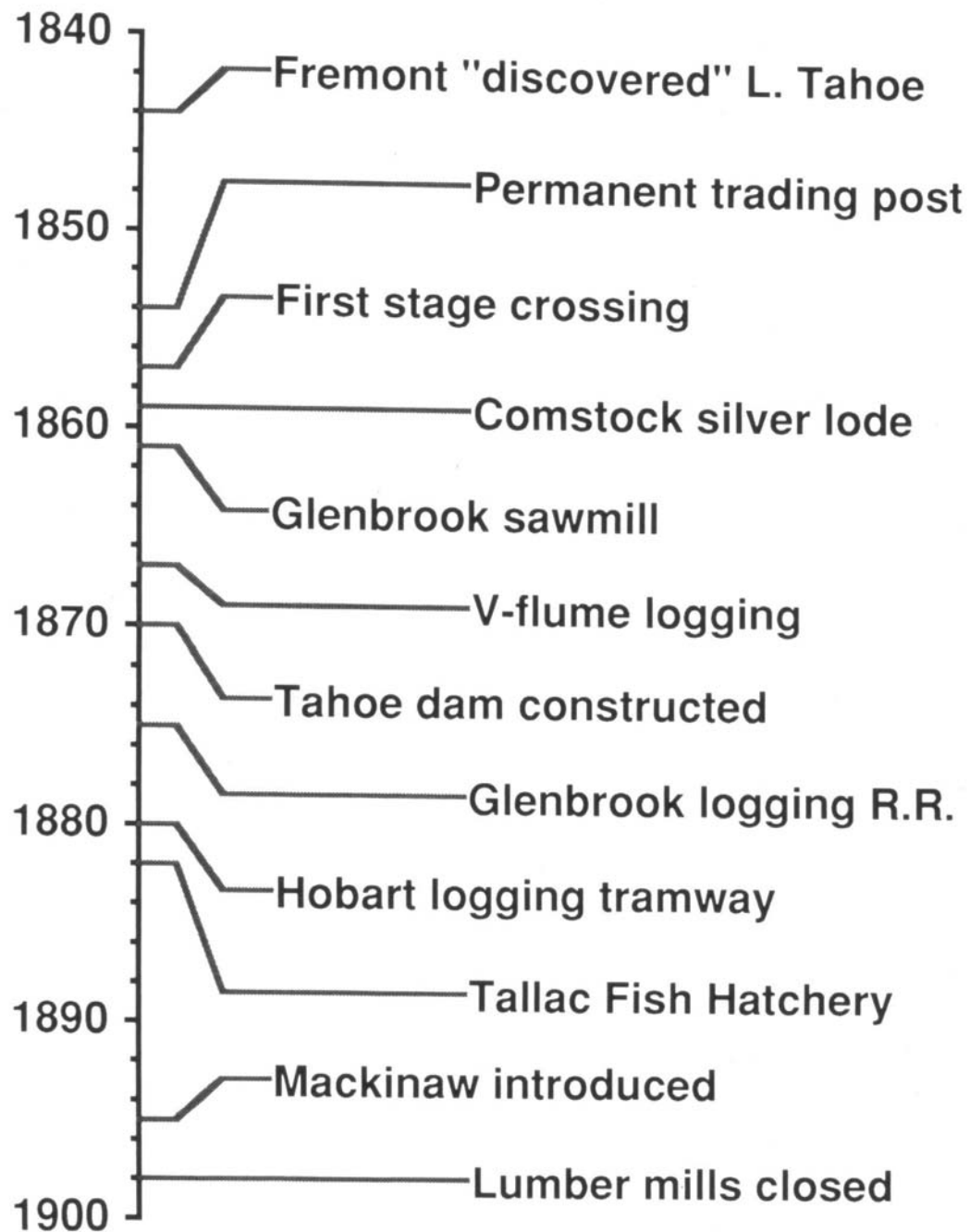
Lakes as Indicators of Ecosystem Stress/Change





The Science

- 1844 General John Fremont discovers Tahoe
- 1860s Basin clear cut for Comstock Mines
- 1887 John LeConte first measurements
- 1937 Hutchinson and Kemmer
- 1958 Goldman measurements

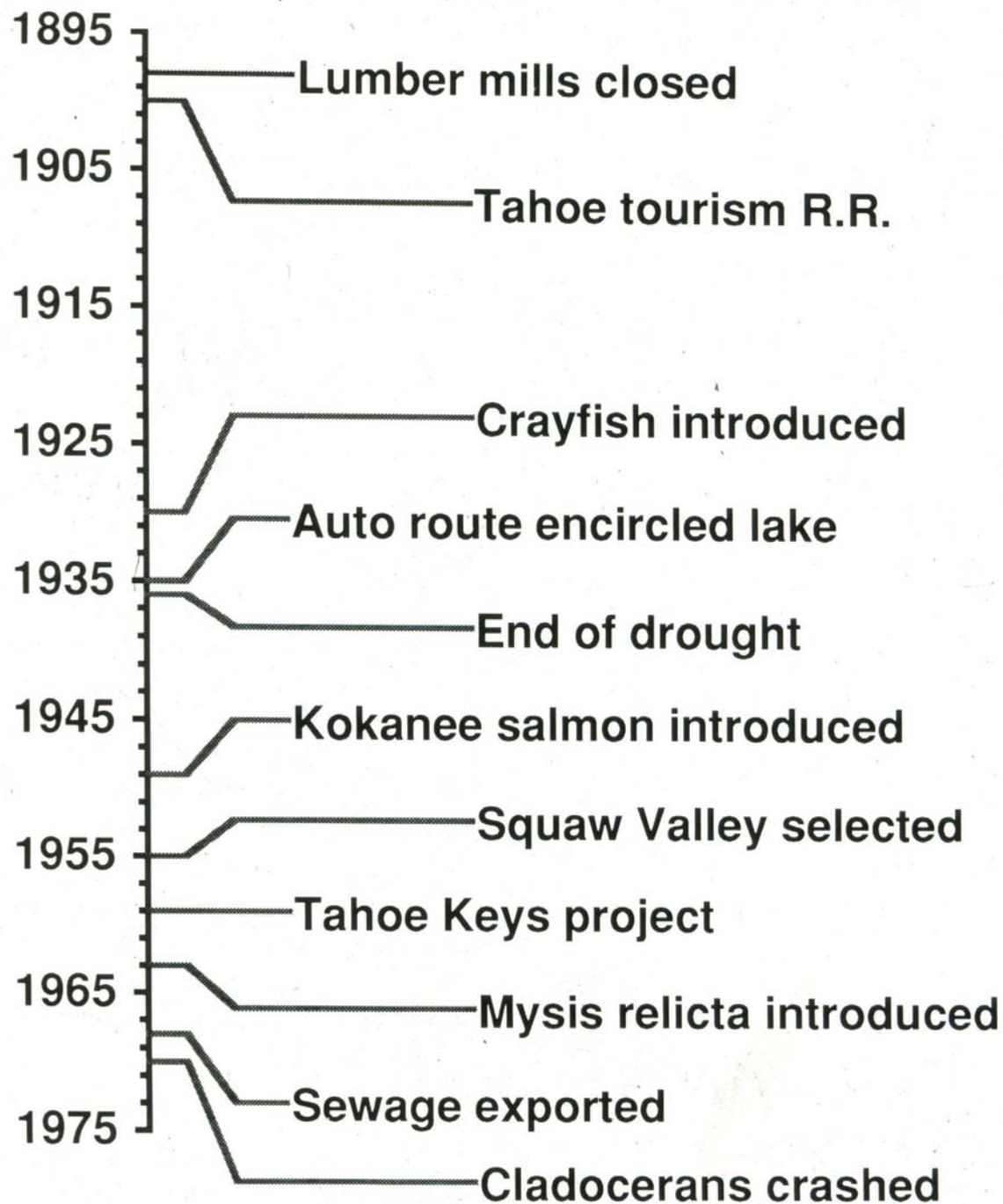




1860

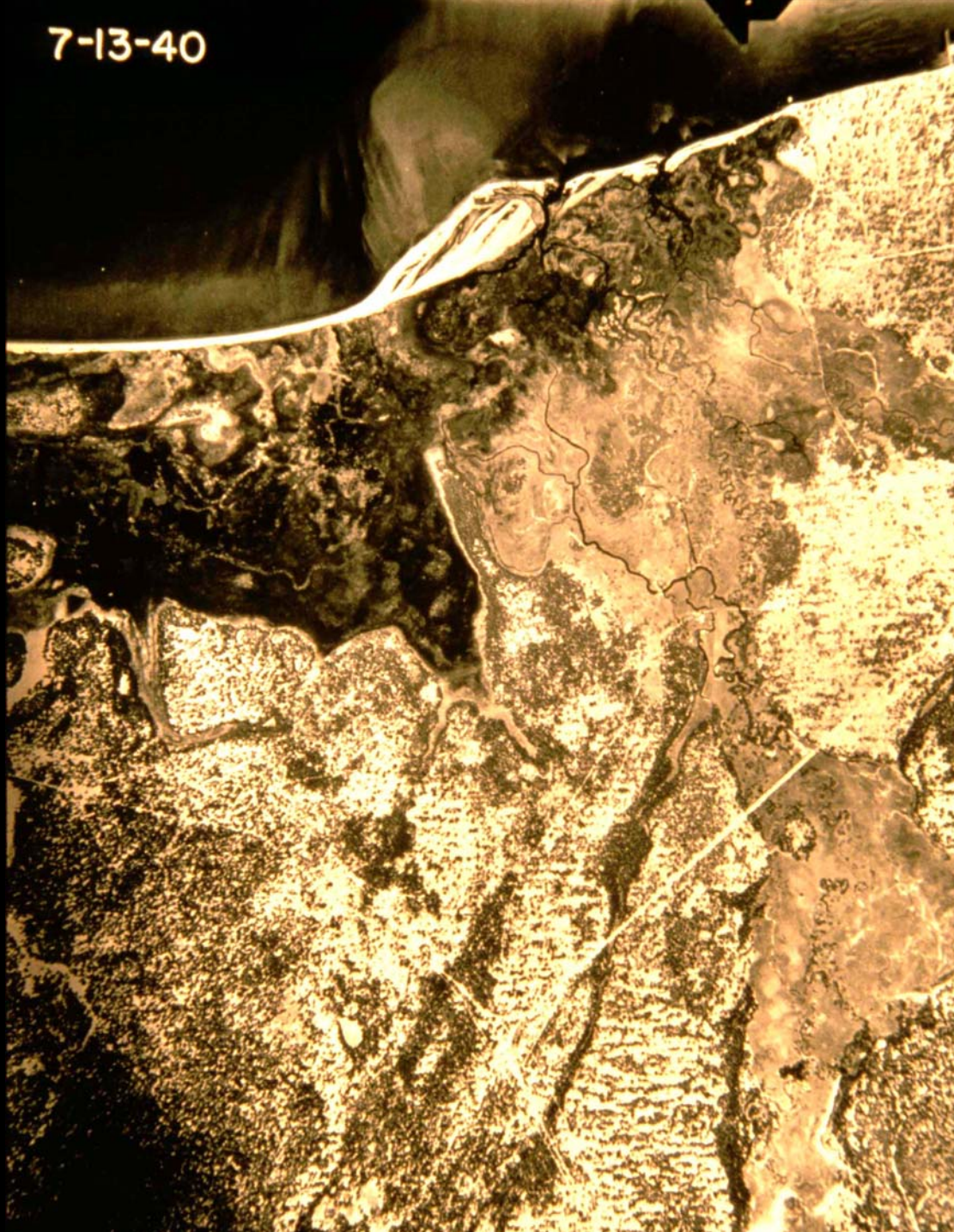
1980







7-13-40



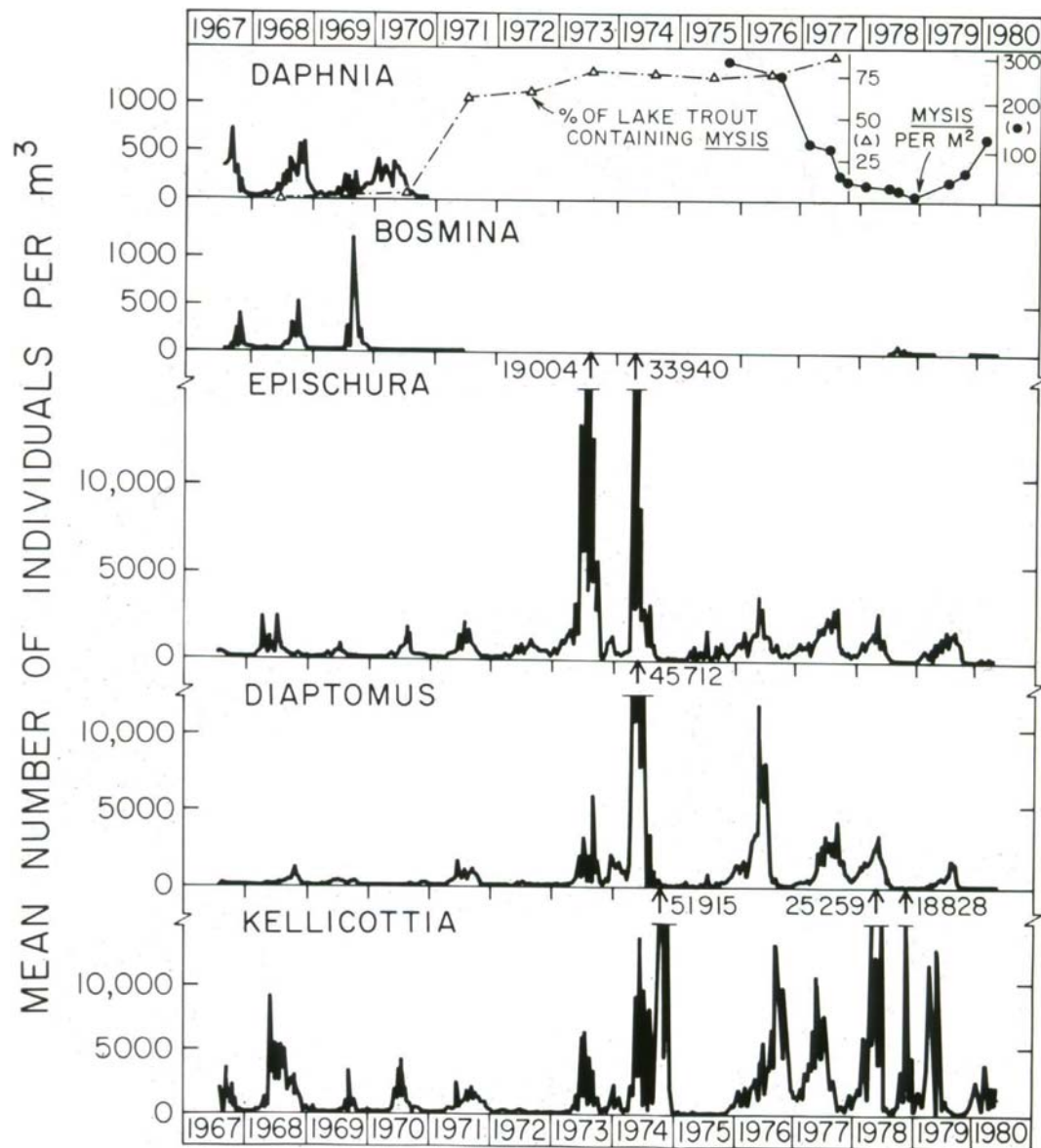




Lake T
South Shore







From: Goldman, C.R. 1981. Lake Tahoe: two decades of change in a nitrogen deficient oligotrophic lake. Verh. Internat. Verein. Limnol. 21.







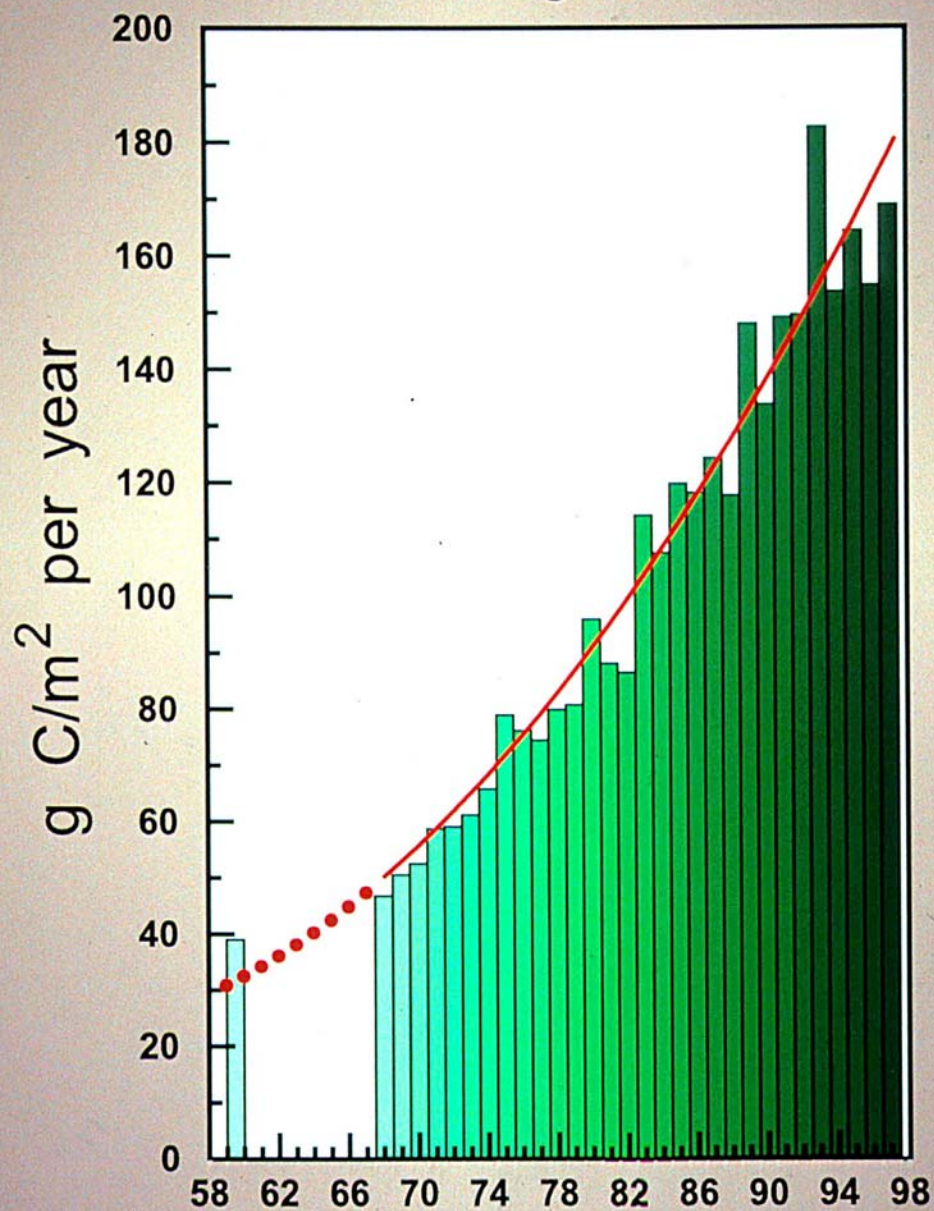


Working Hypothesis

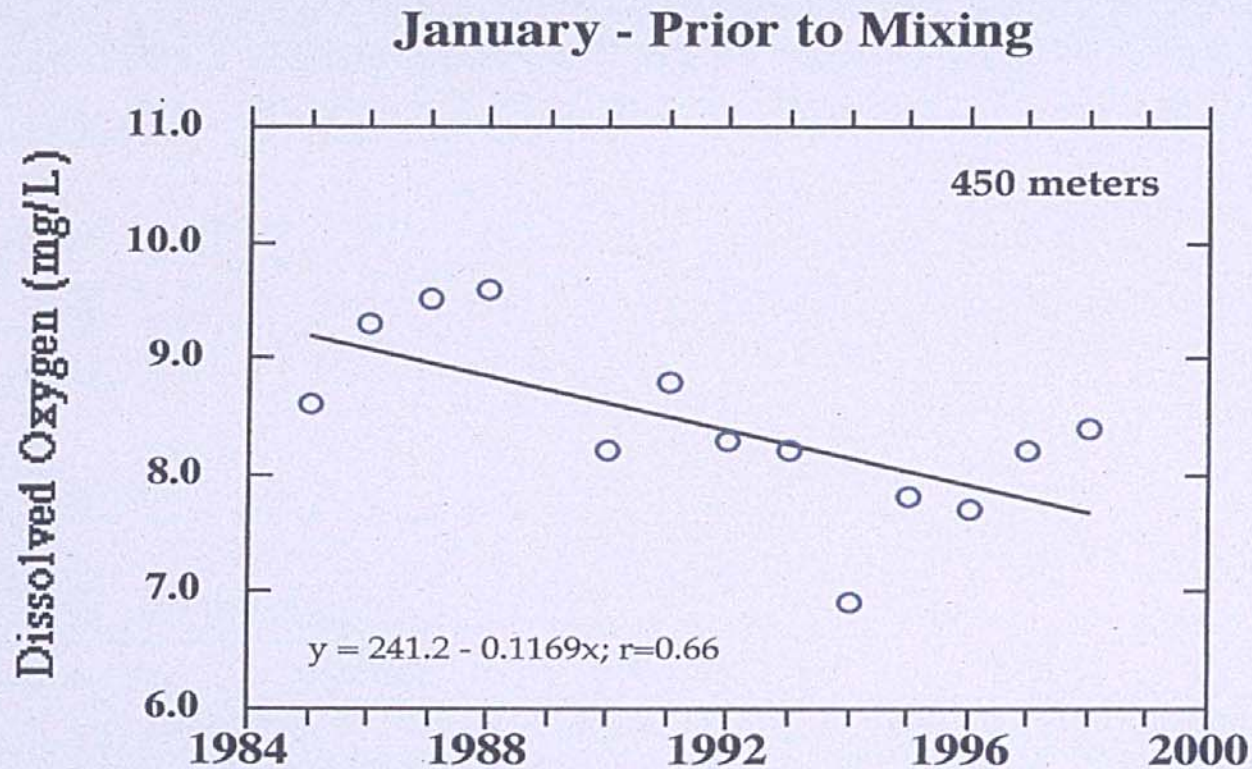
Successful implementation of land, air and water quality restoration projects is considered the only likely avenue available to reduce the accelerated decline in lake clarity.

LAKE TAHOE

Annual Algal Growth

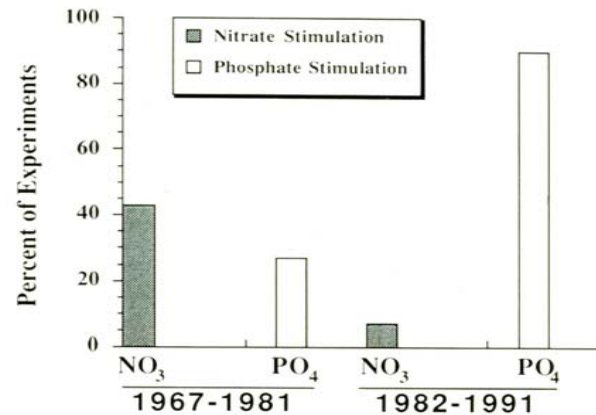


Indication of Potential for Deep-Water Oxygen Loss



Changing Phytoplankton Response to Nutrient Additions

Lake Tahoe Nutrient Bioassays



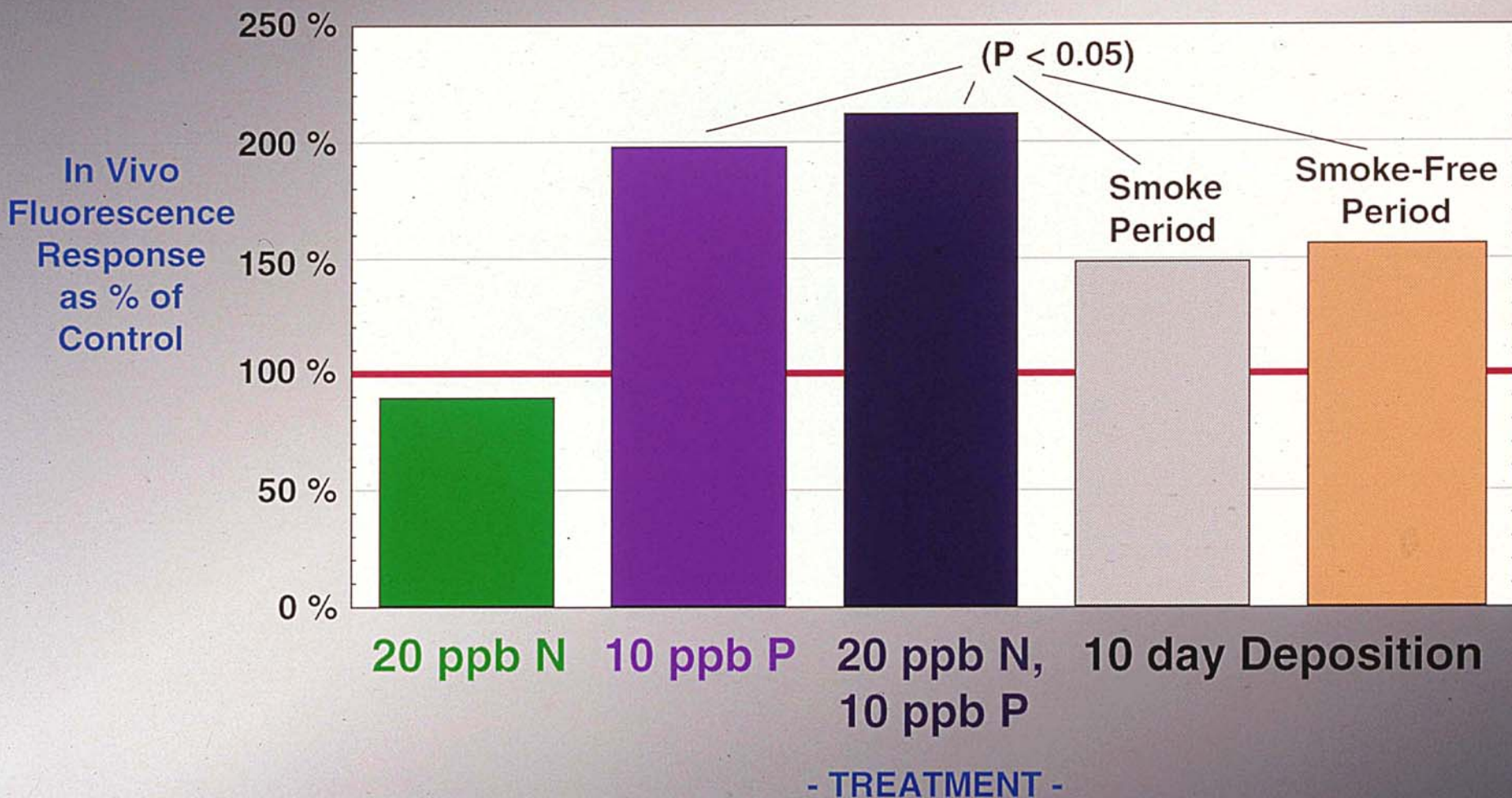
NO_3^- experiments = 58

PO_4^{3-} experiments = 50

Phosphorus Stimulation with +10 ppb addition
40-80%

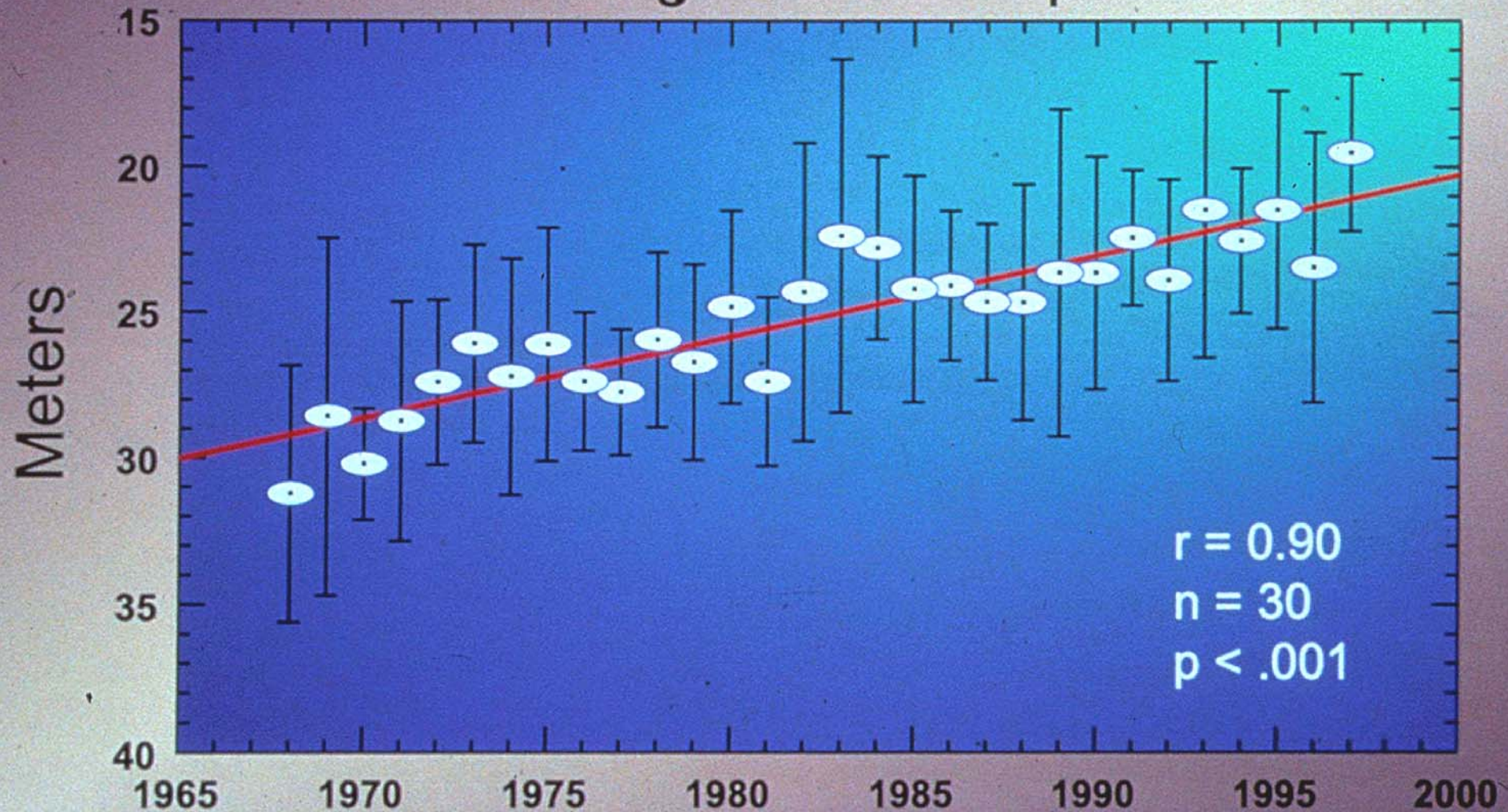
Lake Tahoe Epilimnetic Water Bioassay Responses to Various Treatments

(water collected 16 September, 1996)



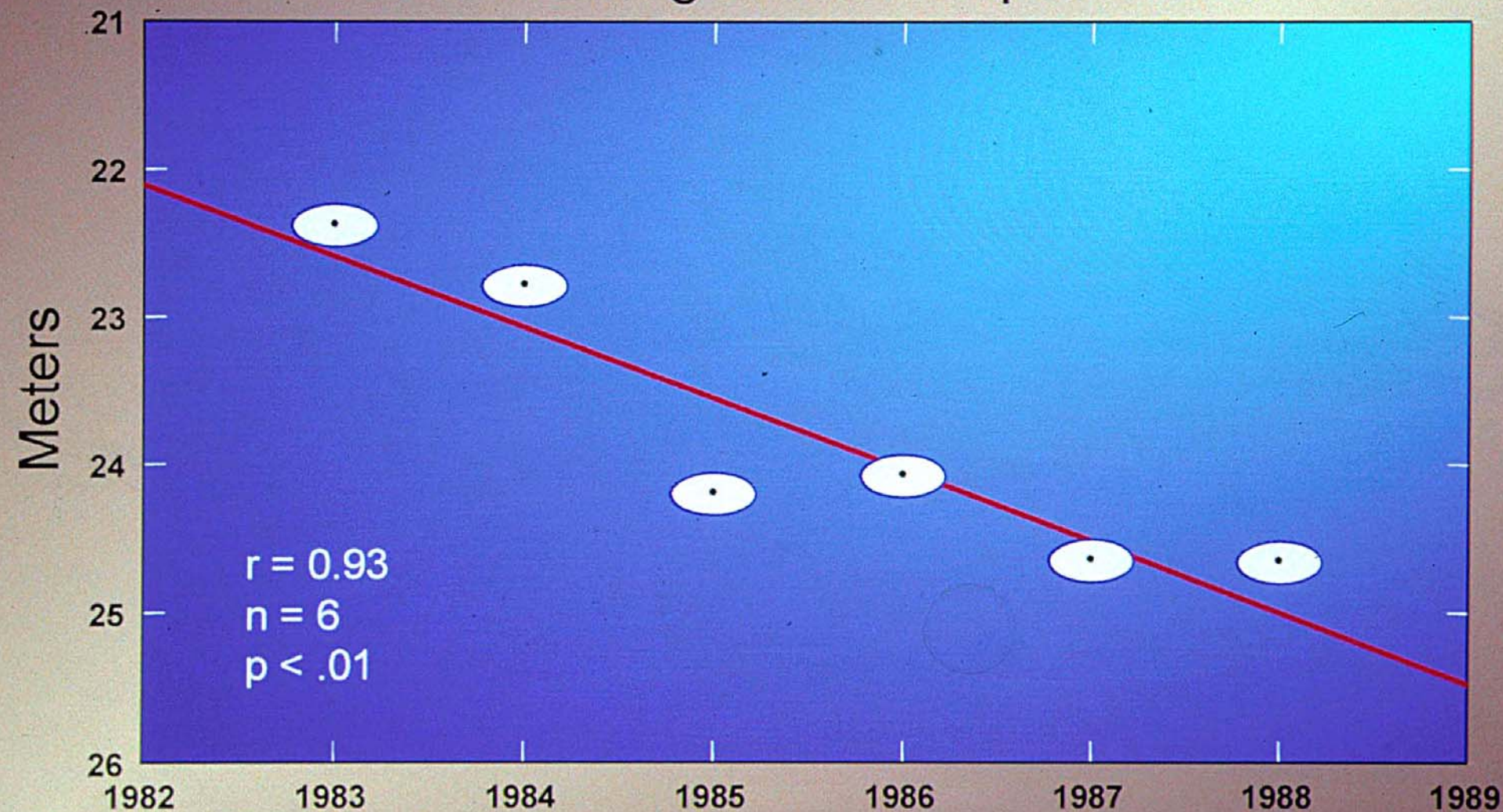
LAKE TAHOE

Annual Average Secchi Depth ± 1 s.d.



LAKE TAHOE

Annual Average Secchi Depth \pm 1 s.d.

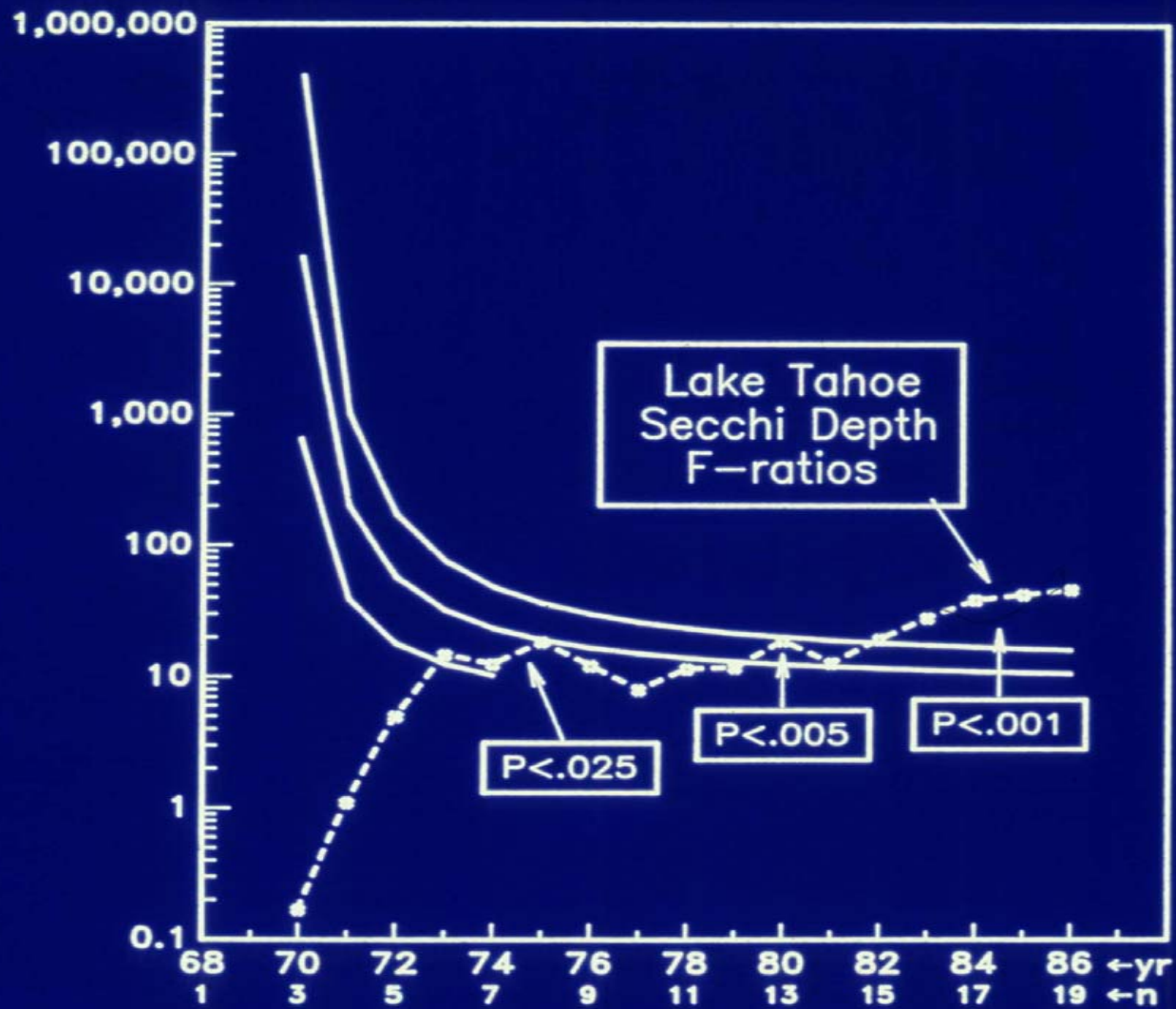


Lake Tahoe Basin

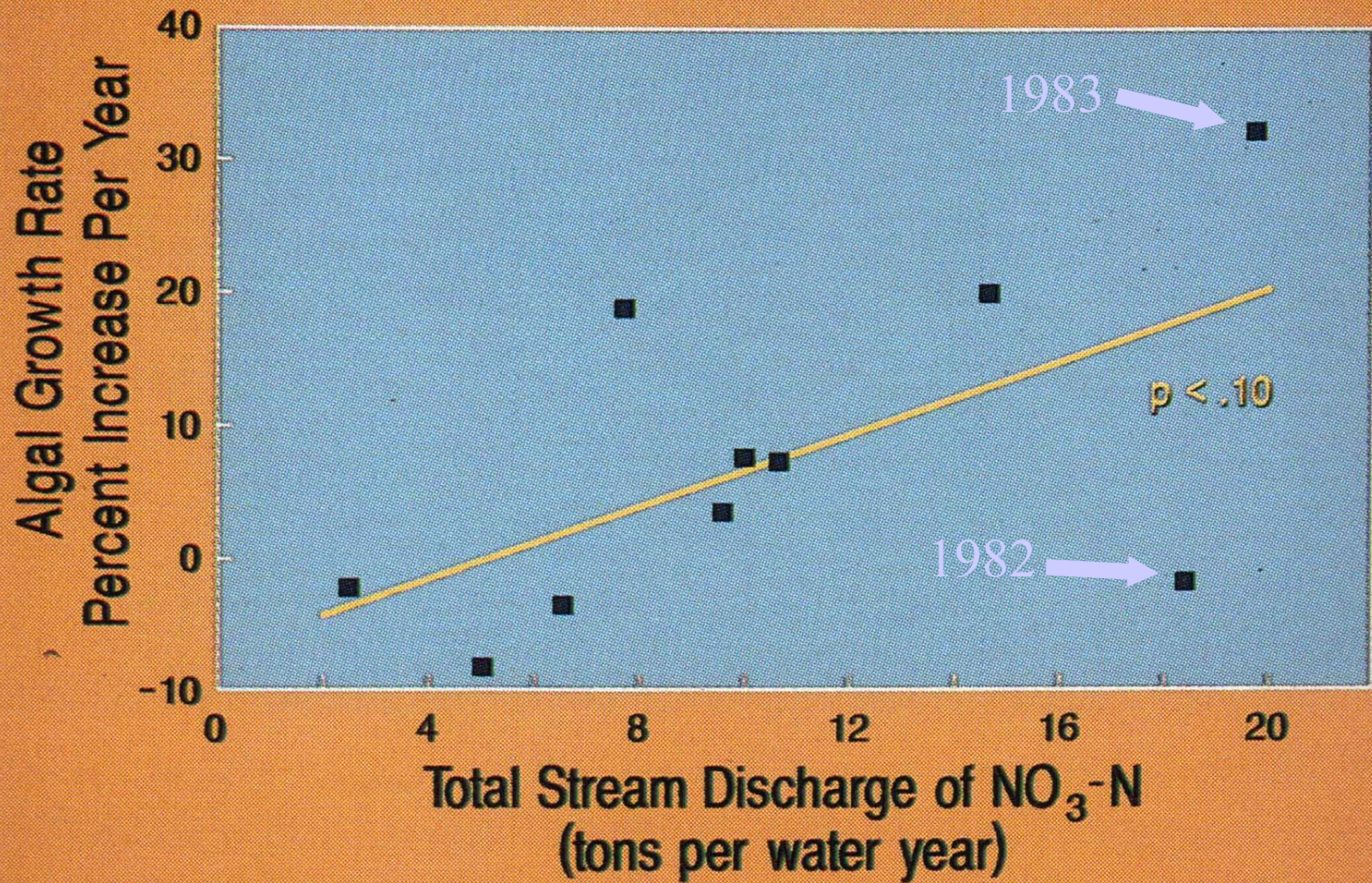
A Changing Watershed

- Significant portions are urbanized
- Increased resident population
- Millions of tourists
- Peak VMT >1,000,000 miles/day
- Loss of wetland and runoff infiltration
- Extensive road network
- Land disturbance - soil erosion
- Air pollution

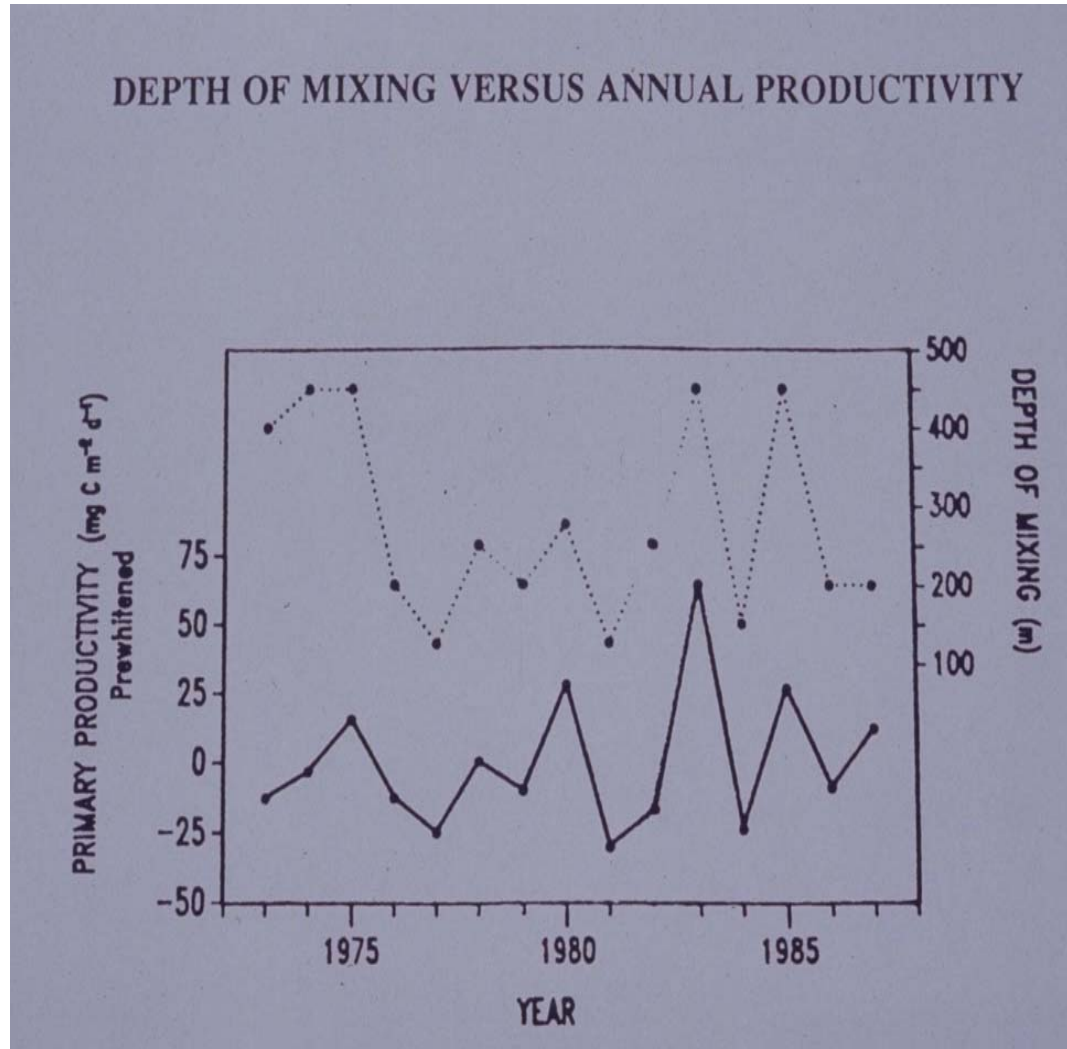
CRITICAL VALUES OF THE F-DISTRIBUTION



LAKE TAHOE



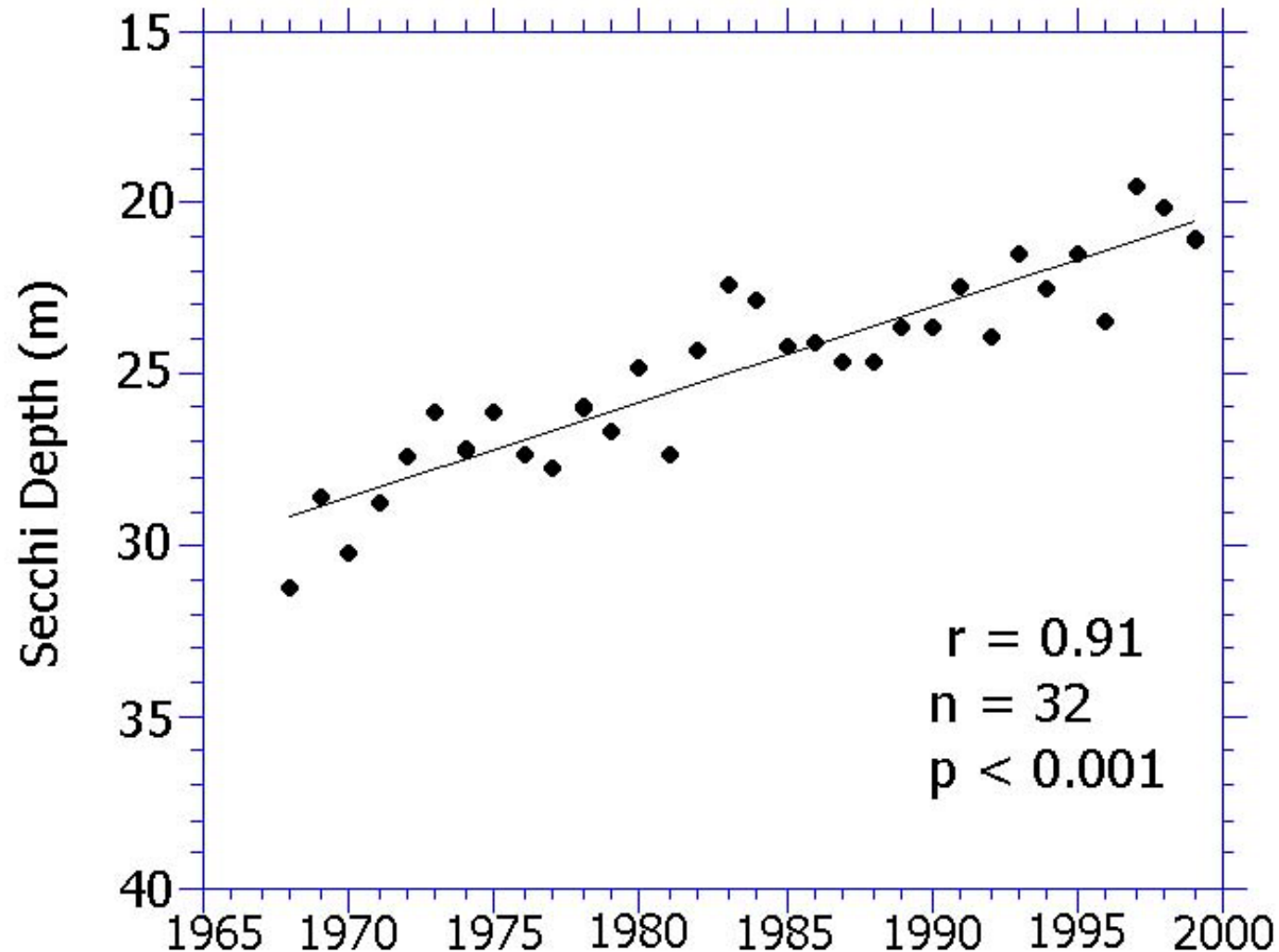
Outlier Lead to Consider Depth of Mixing



Decline in Water Clarity

(Data from UC Davis - Tahoe Research Group)

Mean Annual Secchi Depth



Lake Issues

Lake Clarity as a Management Endpoint

Unraveling the Causes for the Decline

Changing Landscape has Lead to Following Lake Issues

- Loss in transparency
- Increased algal growth
- Changes in biodiversity
- Higher load of nutrients and fine-sediment
- Wetland/riparian habitat loss
- Invasion of non-native biota
- Appearance of toxics (e.g. PCB, Hg, MTBE)

Unraveling Cause(s) for Declining Water Clarity

- Stimulation of algae by increased nutrients
- Fine-sediments also have reduced clarity
- Lake response time to equilibrium requires decades
- Progressive accumulation of nutrients has lead to long-term transparency decline
- No longer able to dilute pollutants sufficiently to avoid eutrophication

Working Hypothesis Used in Tahoe Basin

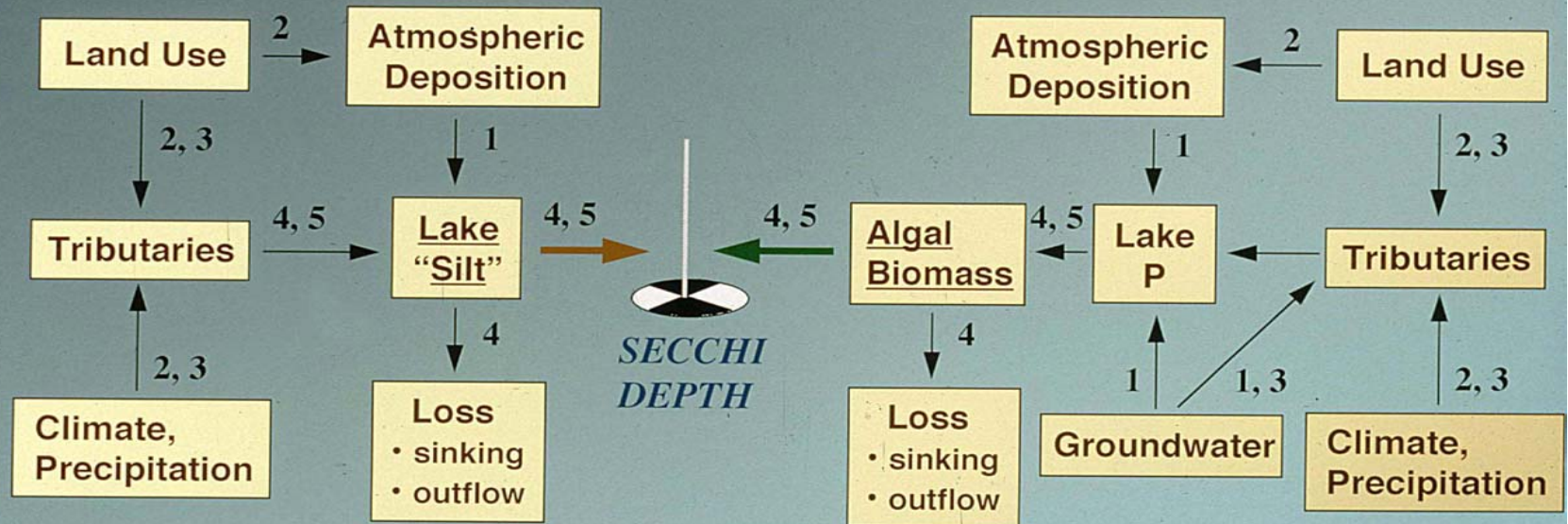
Successful implementation of land, air and water quality restoration projects is considered the only likely avenue available to reduce the accelerated decline in lake clarity.

Solutions Require Quantitative Load Reduction Targets

- Historically, science identified need for nutrient/sediment reduction.
- Silent on question of level of reduction.
- Quantifiable targets for loading and load reduction are needed.

Conceptual Clarity Model

TRG CLARITY MODEL



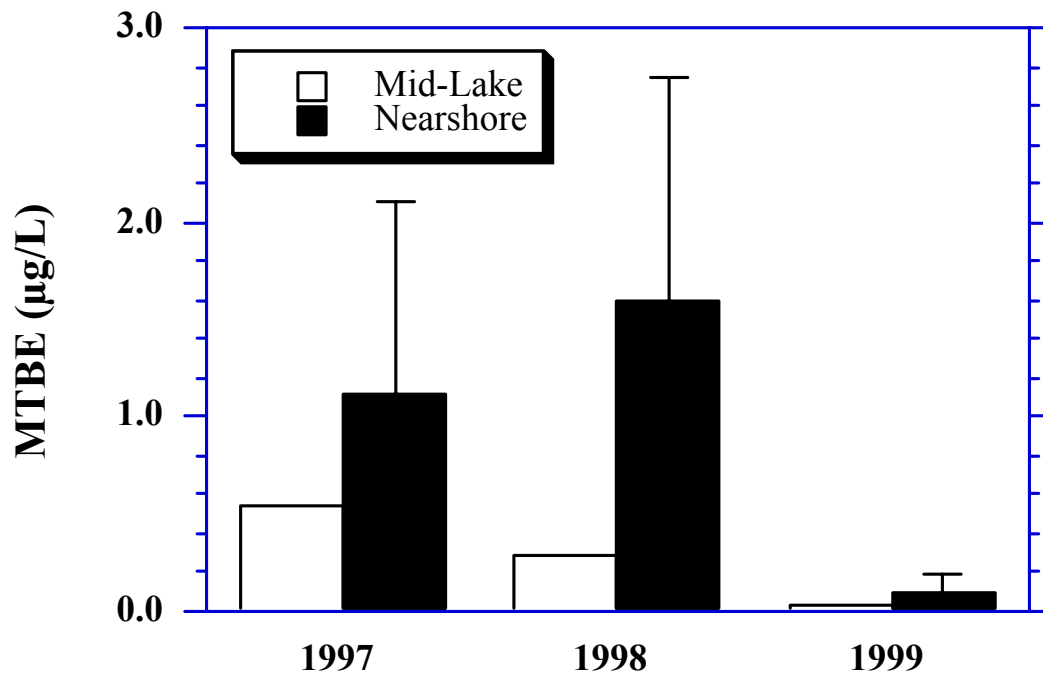
1. Nutrient, Sediment, Water Budgets
2. Loading - Land Use Model
3. Erosion - Transport Model
4. Lake Hydrodynamic & Quality Model
5. Lake Response Model

Lake Tahoe Basin

A Changing Watershed

- Significant portions are urbanized
- Increased resident population
- Millions of tourists
- Peak VMT >1,000,000 miles/day
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- Air pollution

MTBE in Lake Tahoe Surface Waters

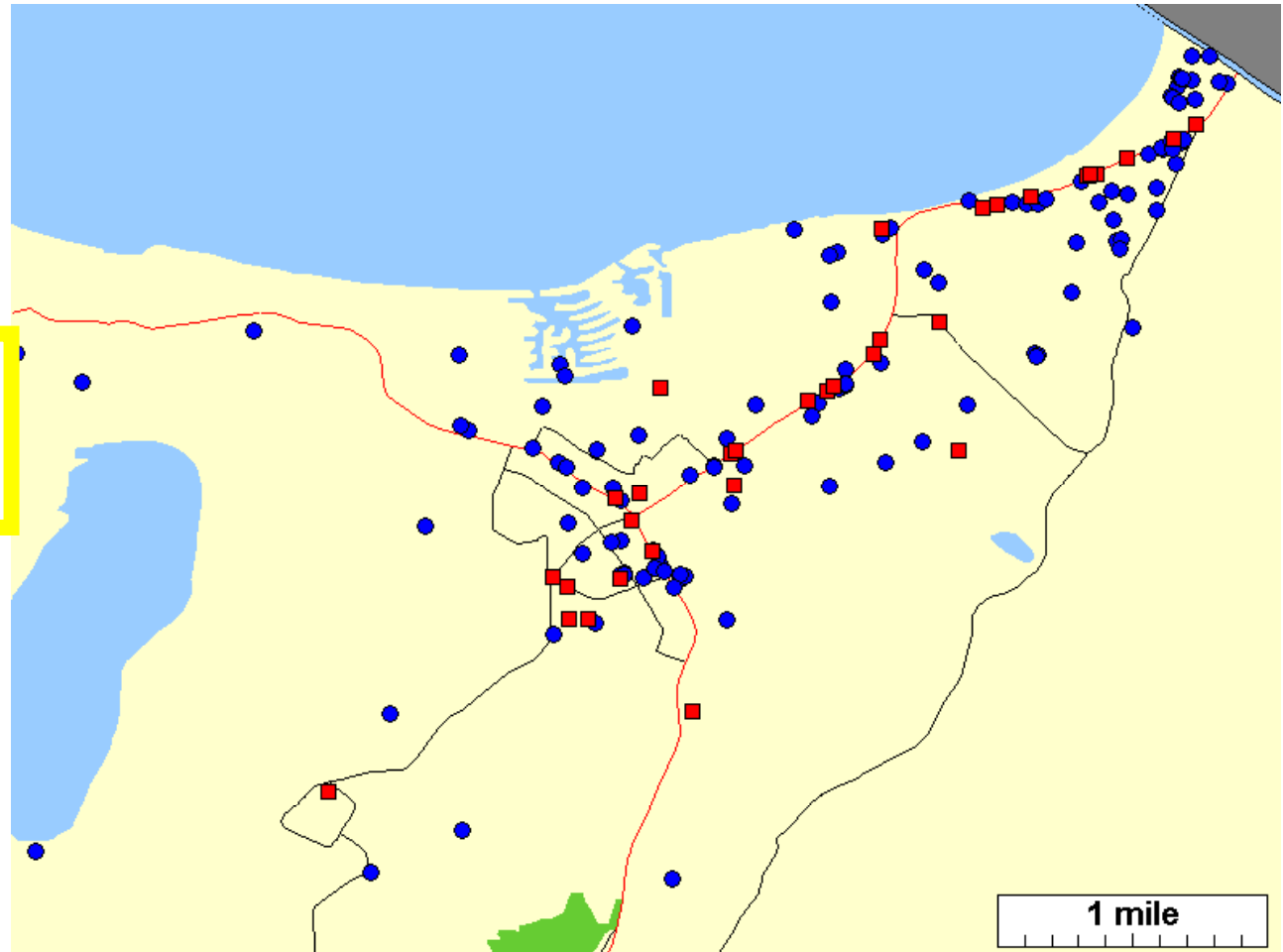


Occurrence of MTBE in Groundwater

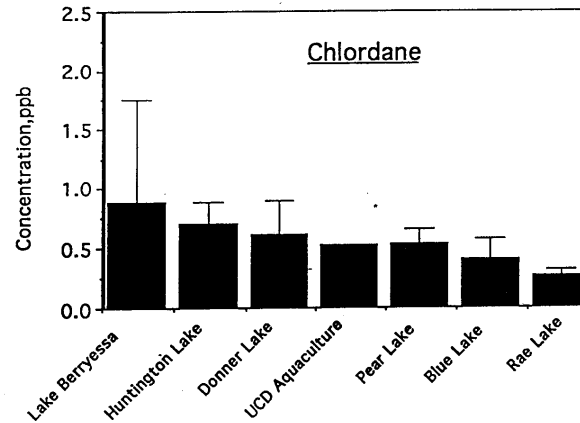
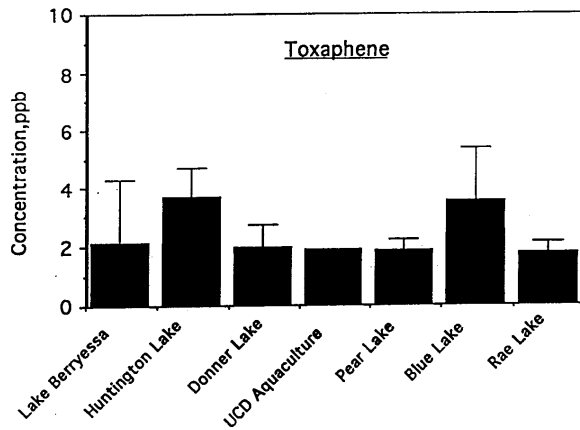
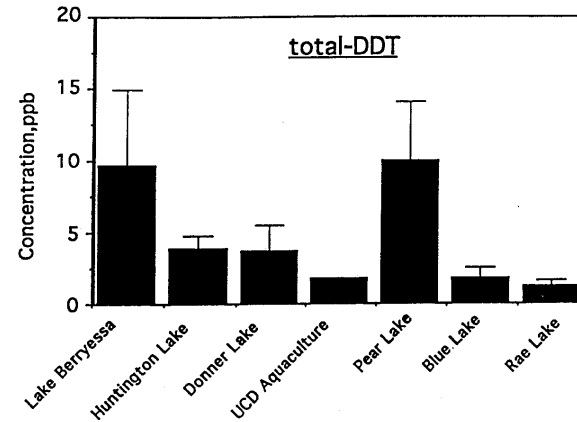
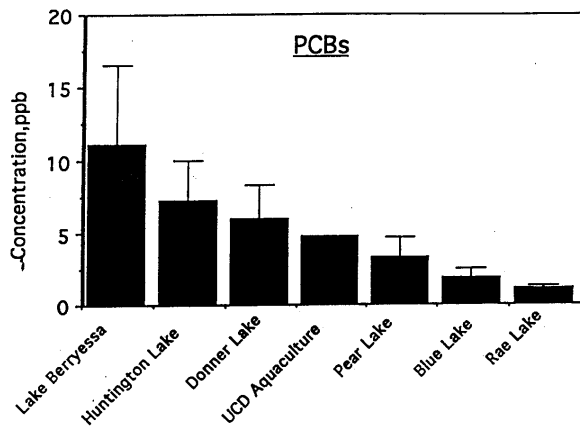
**>20% of South Tahoe municipal supply wells
contaminated or threatened by MTBE plumes in 1998.**

LUFT Sites

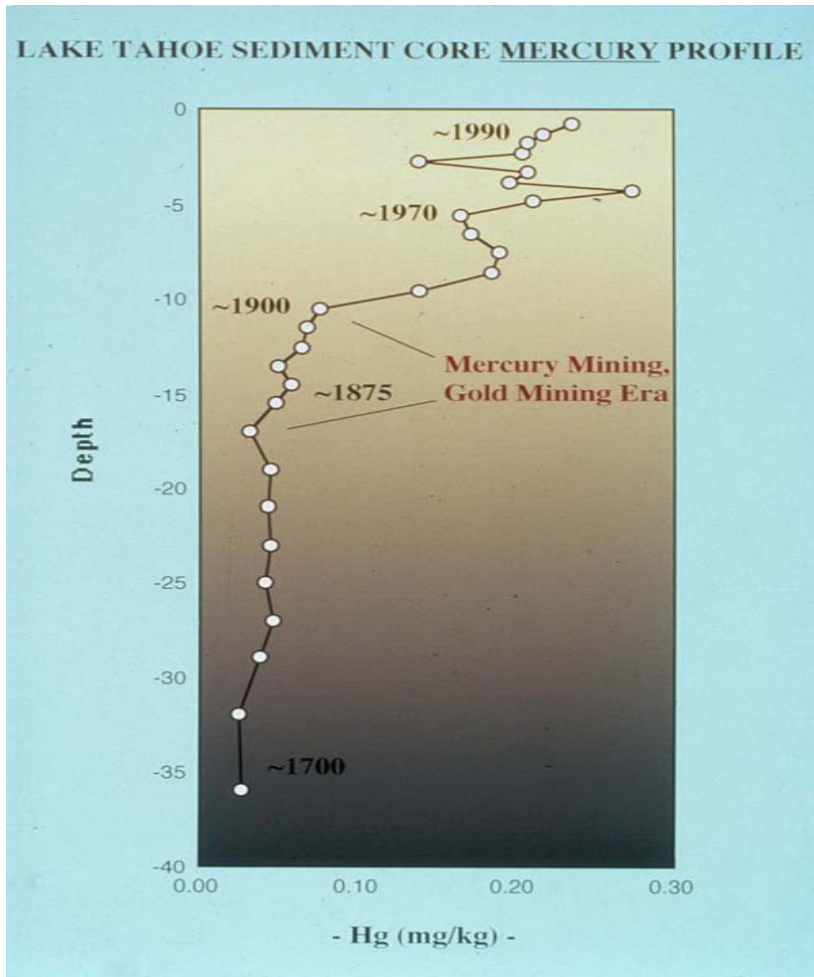
Water Supply Wells



Toxic Organics in Fish



Regional Transport of Mercury



Organizing Science for Management Using the TMDL Approach

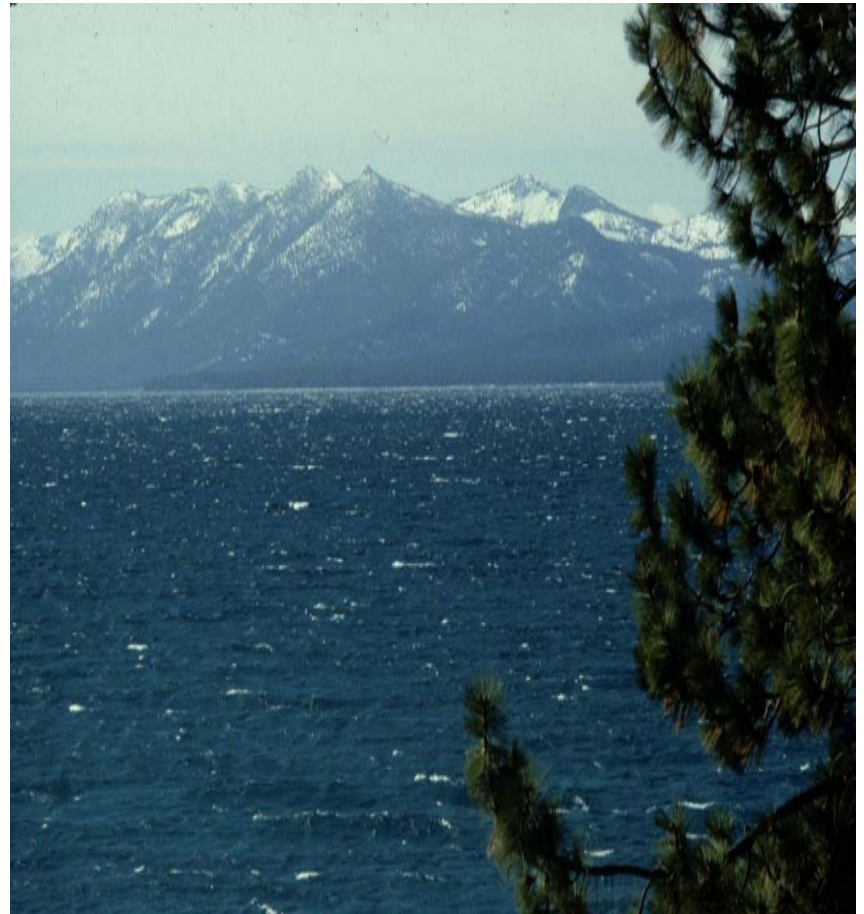
- Definition: Amount of a specific pollutant that a waterbody can receive and maintain its beneficial uses
- US EPA/California approach for managing non-point source pollution
- Good fit with our Working Hypothesis
- UCD Lake Tahoe research working towards this goal for past decade

Define the Problem and ID Pollutants

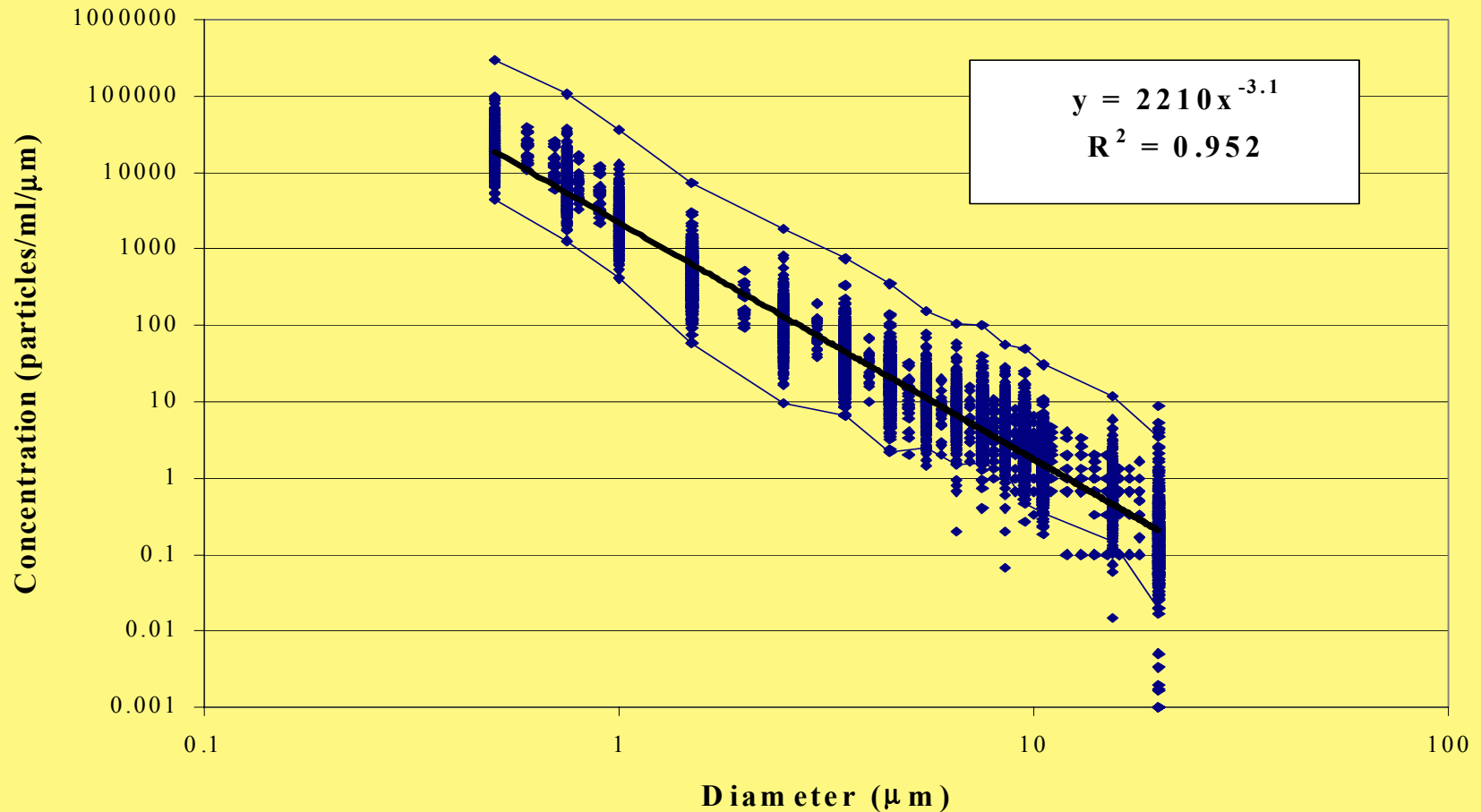
- CEHR research has identified a number of pollutants which have been found in the otherwise pristine waters of Lake Tahoe

TMDL Elements

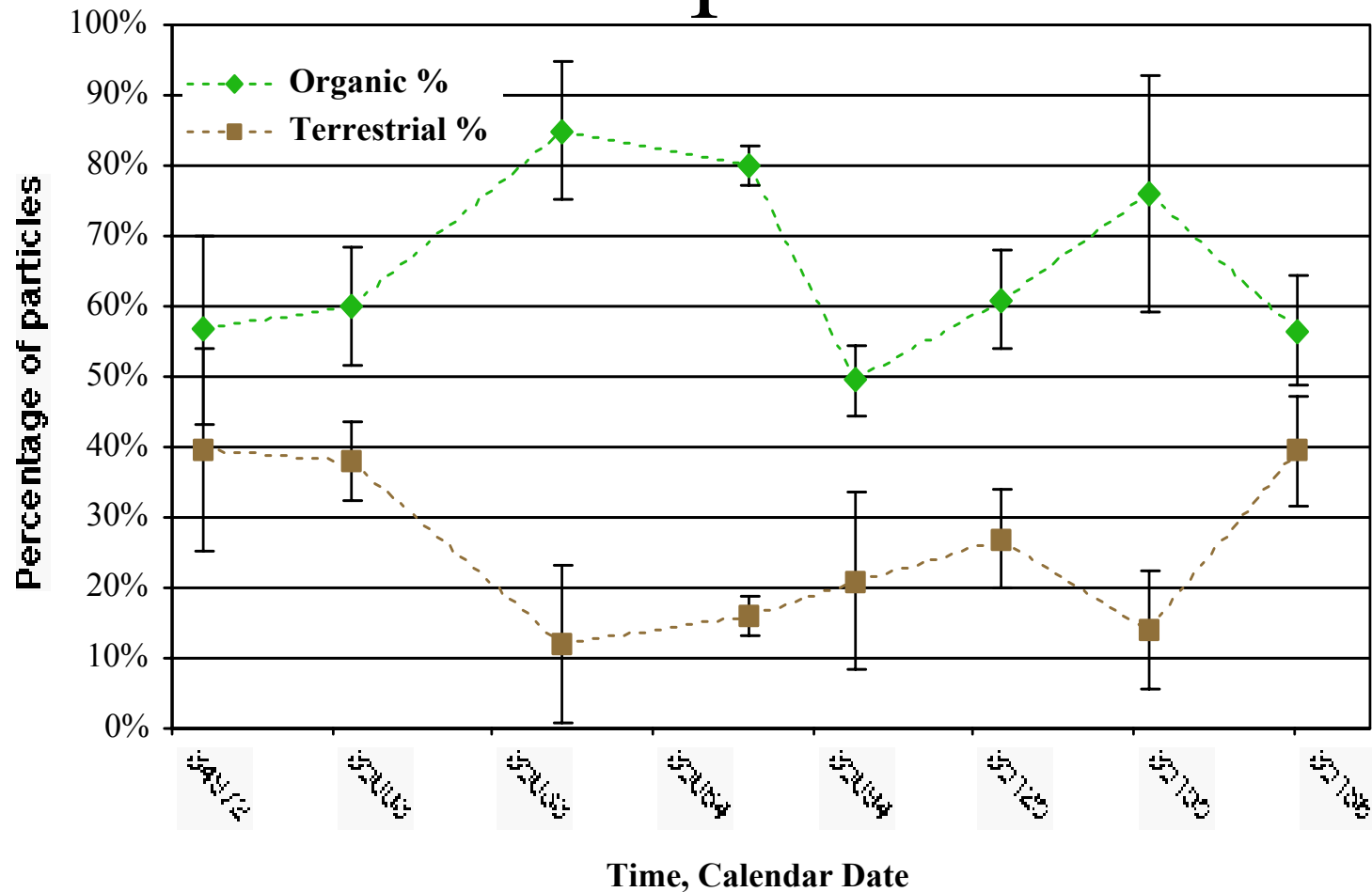
- Define problem
- Define numeric targets
- Identify pollutant sources
- Linkage between loading and response
- Pollutant allocation
- Monitoring needs



Study of Lake Tahoe Particles Size Distribution



Study of Lake Tahoe Particles Composition



Identify Sources and Evaluate Pollutant Loading

- Water budget
- Nutrient budget
- Stream phosphorus transport
- Stream sediment transport

P - Removal by Natural Wetlands in Tahoe Basin

- Existing natural wetlands
= 75.8 ha
- Mean P accumulation
based on wetland cores
= 0.22 ± 0.05 g P/m²/yr
- To remove significant
amounts of P a much
larger wetland is needed
- Under current hydrology,
natural wetlands may not
be answer

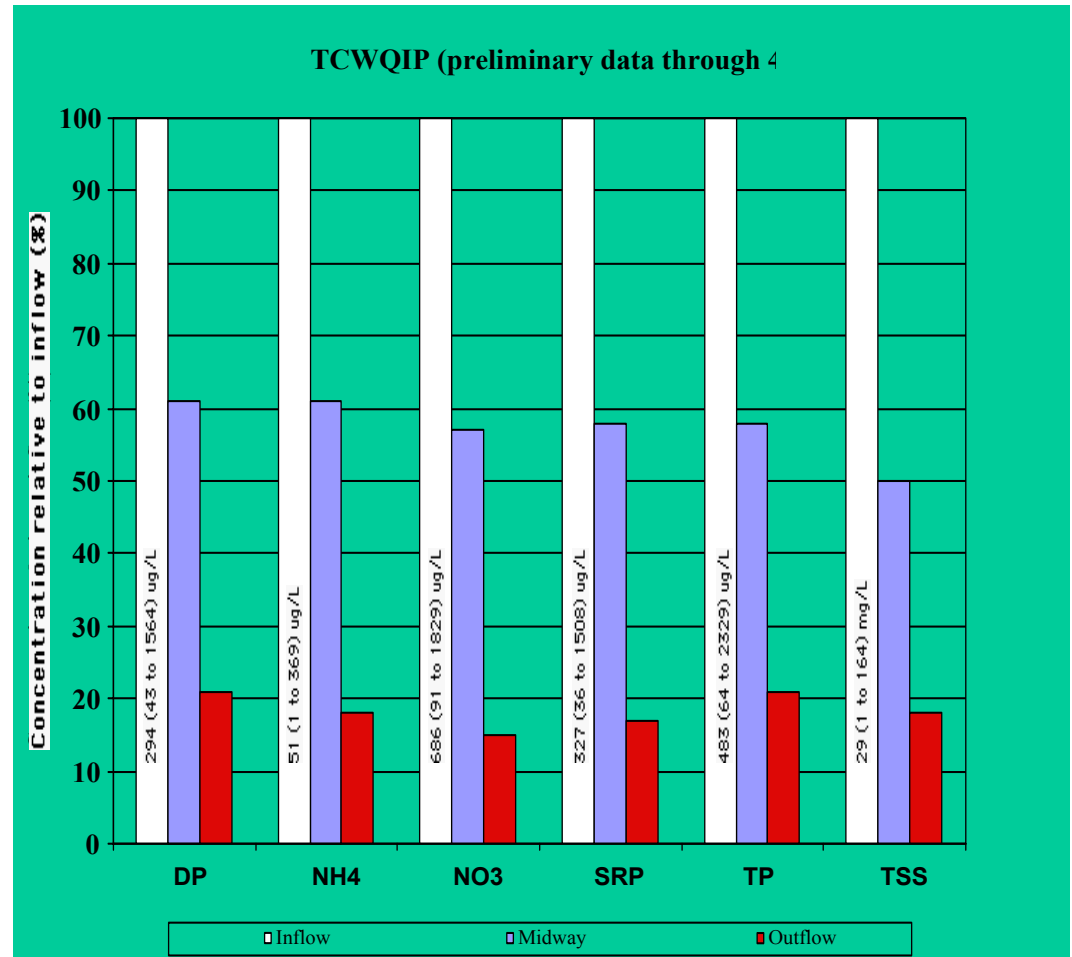
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P - Removal by Constructed Wetlands at Tahoe City

- New research
- Preliminary results showing an 80% reduction in most pollutants
- P-accumulation calculated at 1.1g P/m²/yr, ie. 5x natural wetland





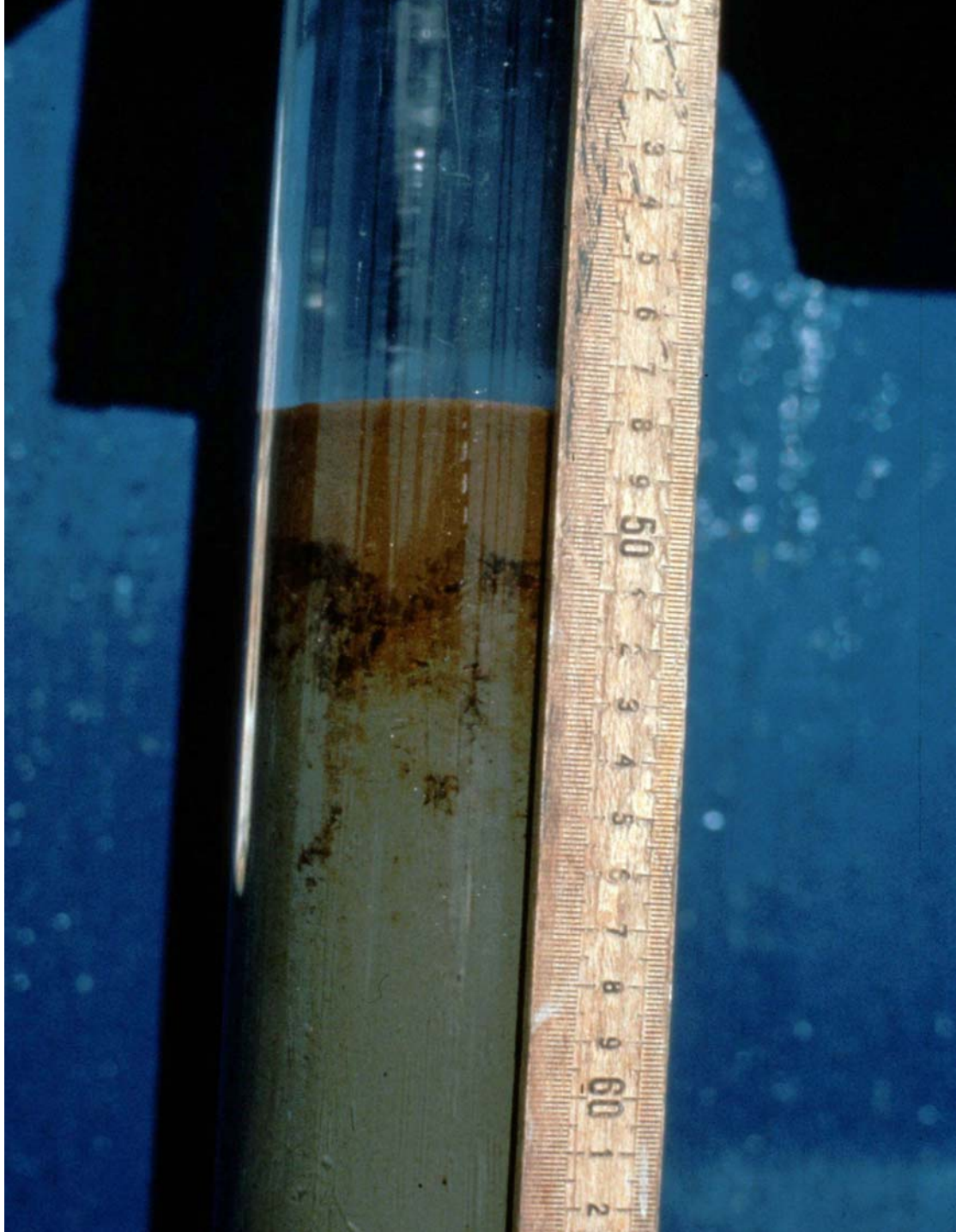




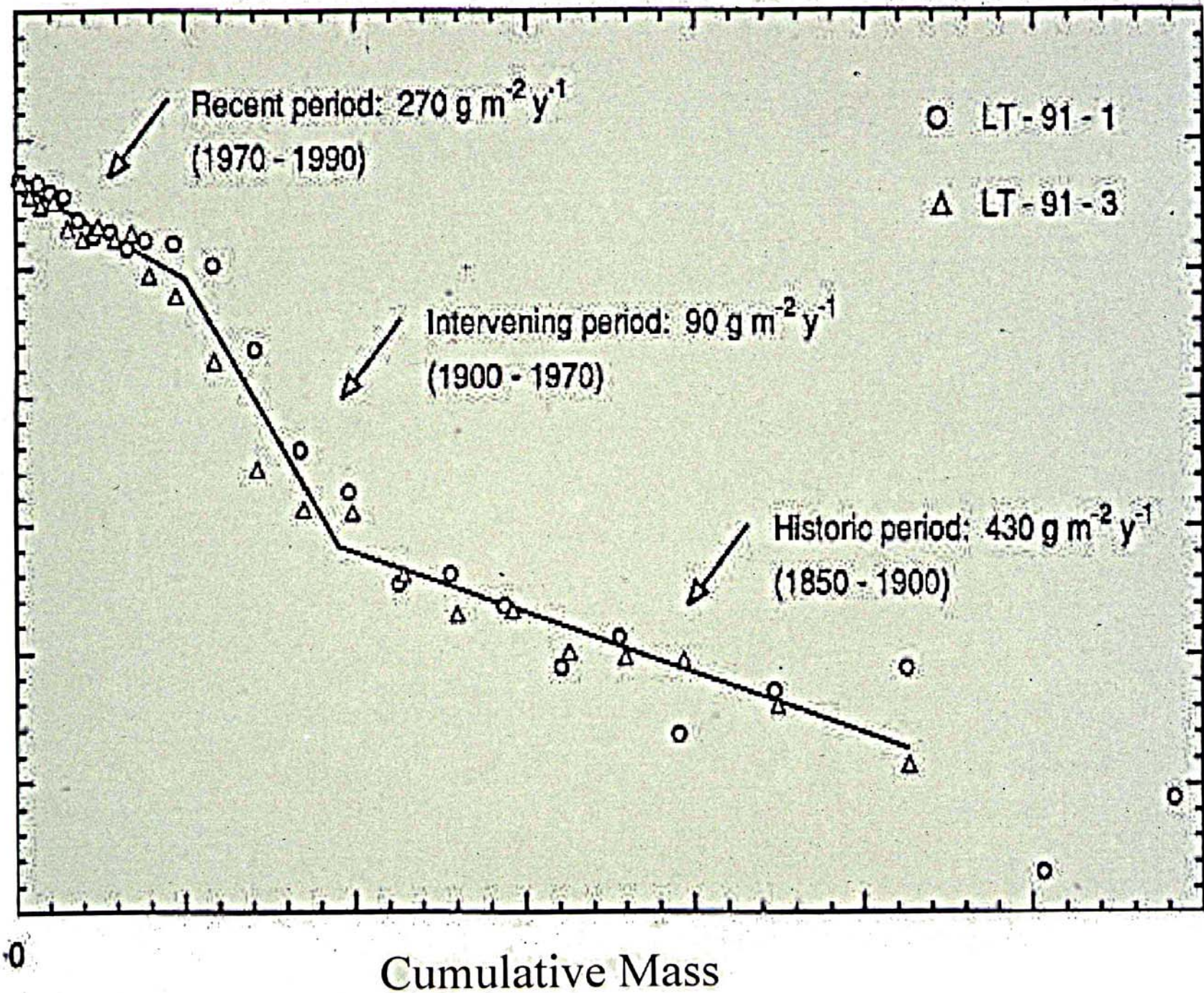
Key Points

- Watershed and air quality-based restoration is the only avenue to arrest the decline in clarity
- A science based understanding is essential for management and planning

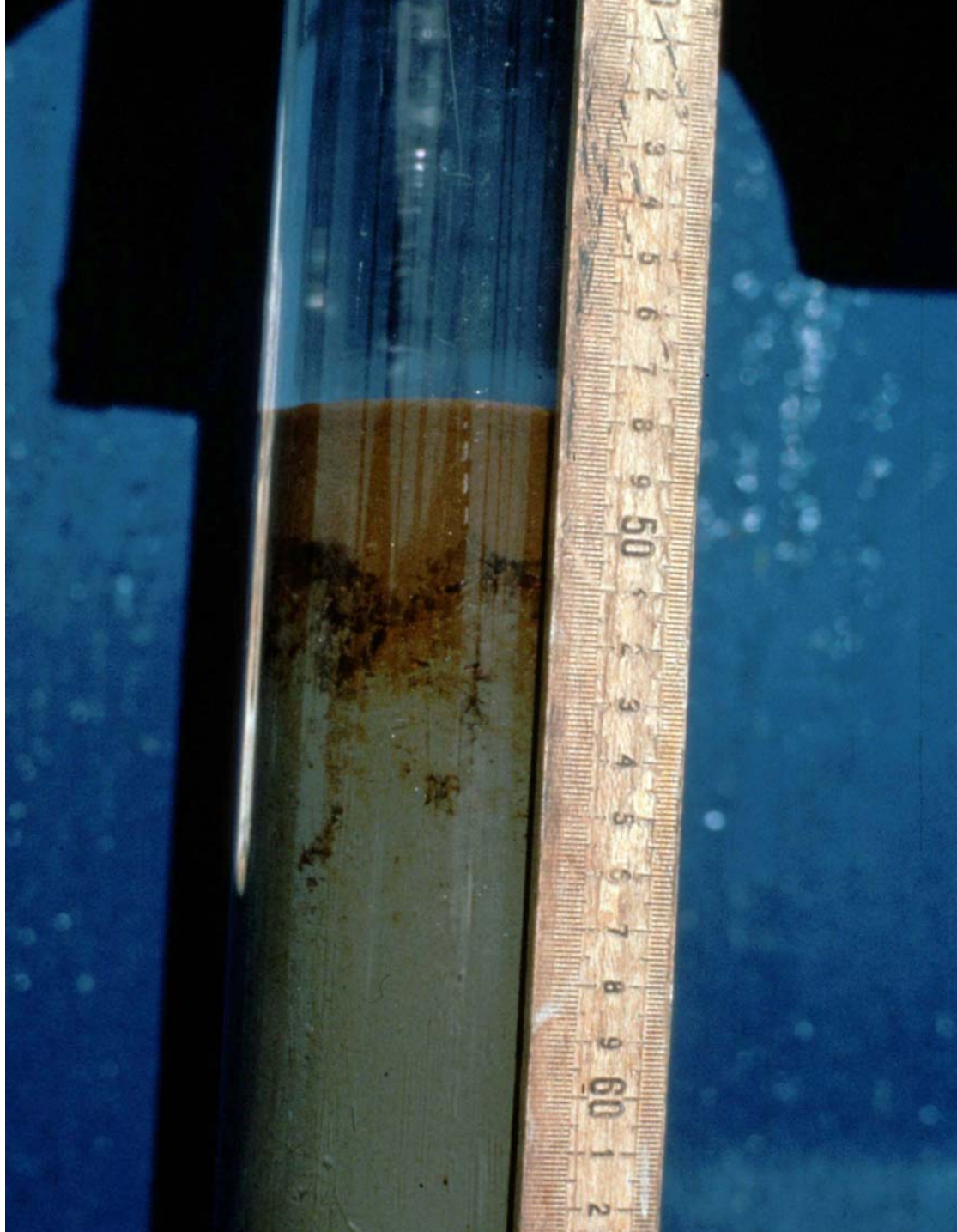




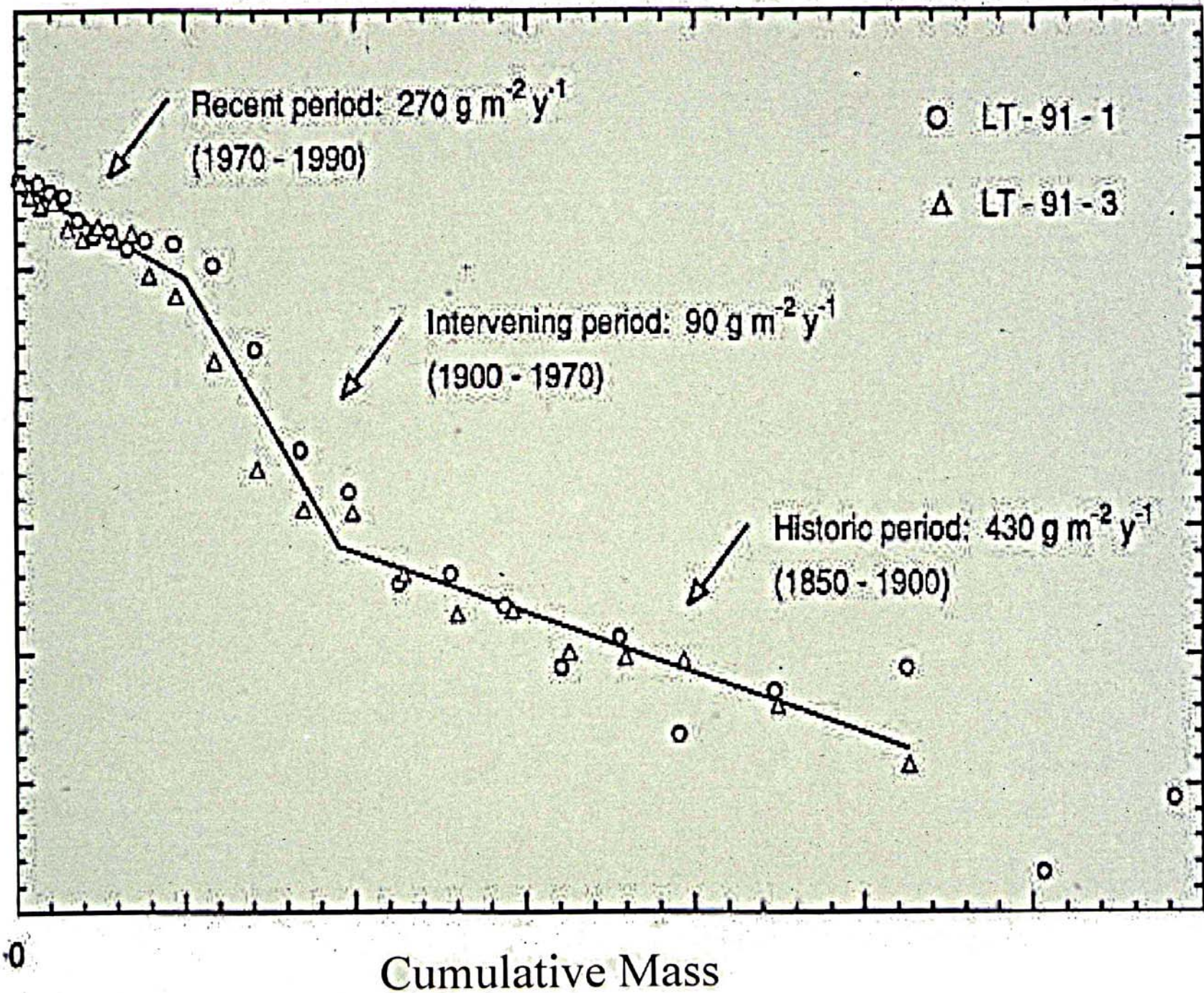
\log_e excess ^{210}Pb activity (pCi g^{-1})







\log_e excess ^{210}Pb activity (pCi g^{-1})





CHANGING WATER QUALITY AT LAKE TAHOE:

The First Five Years of The Lake Tahoe Interagency Monitoring Program

Prepared for the California State Water Resources Control Board by
Charles R. Goldman and Earl R. Byron



Tahoe Research Group, Institute of Ecology
University of California, Davis, California 95616





Bee photographs/Jay Mather

President Clinton and Vice President Al Gore examine Lake Tahoe water samples with lake researcher

Charles Goldman, right. "The minute we got on the boat I got my Biology 101 course," Clinton said.









THANKS
for all your
SUPPORT,
SUGGESTIONS
and for the
MEMORIES !!!



CEHR

An Enlightening Experience



Acknowledgements

Principal Investigators

Cort Anastasio

Levent Kavvas

Michael Barbour

Fumio Matsumura

John Carroll

Eliska Rejmankova

Graham Fogg

John Reuter

Charles Goldman

David Rizzo

Alan Heyvaert

Darrell Slotton

Richard Higashi

Geoff Schladow

Alan Jassby